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Aquatic Invertebrates and Habitat of
McClellan Creek, Jefferson County, Montana.
August 2001. A Bioassessment Study.

Bollman, W.

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**AQUATIC INVERTEBRATES AND HABITAT OF
McCLELLAN CREEK,
JEFFERSON COUNTY, MONTANA**

August 2001

A BIOASSESSMENT STUDY

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A report to

**The Montana Department of Environmental Quality
Helena, Montana**

by

**Wease Bollman
Rhithron Associates, Inc.
Missoula, Montana**

September 2002

INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected on August 7-8, 2001 from 2 sites on McClellan Creek, a tributary of Prickly Pear Creek in Jefferson County, Montana. Aquatic invertebrate assemblages were sampled by personnel of the Montana Department of Environmental Quality (DEQ). Study sites lie within the Montana Valley and Foothill Prairies ecoregion (Woods et al. 1999). A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "... a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied is needed to assist in the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to habitat assessment parameters, and consistent over replicated samples.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by metals, other toxicants, high water temperatures, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting.

Table 1. Sample designations and sampling sites. McClellan Creek, August 7-8, 2001.

Sample name	Site description	GPS location	
		Latitude	Longitude
M07MCCLC01	1.5 miles south of East Helena	46°33'17"N	111°54'31"W
M07MCCLC02	Below Crystal Creek and other small tributary	46°29'09"N	111°52'09"W

disturbance than with natural environmental gradients (Bollman 1998). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. Ephemeroptera (mayfly) taxa richness. The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.

2. Plecoptera (stonefly) taxa richness. Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.

3. Trichoptera (caddisfly) taxa richness. Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.

4. Number of sensitive taxa. Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998).

5. Percent filter feeders. Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsygid caddisflies (*Arctopsyche* spp. and *Parapsyche* sp.) build silken nets with large mesh sizes that

capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. Percent tolerant taxa. Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

Table 2. Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998).

<i>metric</i>	<i>Score</i>			
	3	2	1	0
Ephemeroptera taxa richness	> 5	5 - 4	3 - 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 - 5	5.01 - 10	10.01 - 25	> 25
Percent tolerant taxa	0 - 5	5.01 - 10	10.01 - 35	> 35

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for

inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman, unpublished data). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman, unpublished data).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman, unpublished data).

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis, 1997).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

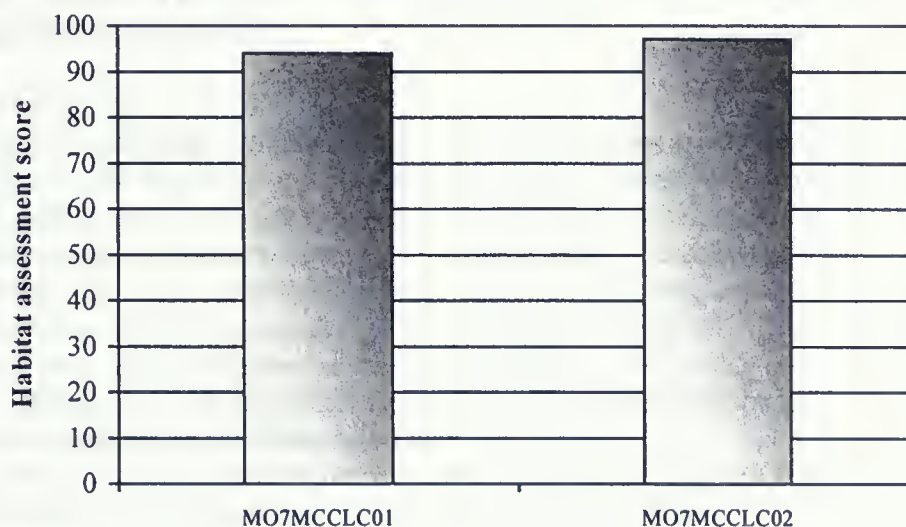
% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

RESULTS

Habitat assessment

Figure 1 compares habitat assessment results for the 2 sites visited. Table 4 itemizes the evaluated habitat parameters and shows the assigned scores for each.

Figure 1. Total habitat assessment scores for 2 sites on McClellan Creek. August 7-8, 2001.



Page No. _____ Date _____

Part A	
1. Name of the candidate	_____
2. Roll No.	_____
3. Date of examination	_____
4. Name of the subject	_____
5. Name of the teacher	_____
6. Name of the school	_____
7. Name of the place	_____
8. Name of the district	_____
9. Name of the state	_____
10. Name of the country	_____

Part B

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____



Table 4. Stream and riparian habitat assessment. Two sites on McClellan Creek. August 7-8, 2001.

Max. possible score	Parameter	MO7MCCLC01	MO7MCCLC02
10	Riffle development	6	10
10	Benthic substrate	9	9
20	Embeddedness	20	20
20	Channel alteration	20	20
20	Sediment deposition	15	20
20	Channel flow status	20	20
20	Bank stability: left / right	10 / 10	8 / 8
20	Vegetated zone: left / right	10 / 10	10 / 10
20	Riparian zone width: left / right	10 / 10	10 / 10
160	Total	150	155
	Percent of maximum CONDITION*	94 OPTIMAL	97 OPTIMAL

*Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. From Plafkin et al. 1988.

Habitat assessment scores indicate optimal conditions at both visited sites. At the downstream site (MO7MCCLC01), substrates were described as a mix of small boulders, large cobble, and occasional bedrock. Some fine sediment deposition may have diminished depths of small plunge pools.

At the upstream site (MO7MCCLC02), the field investigator reported a Rosgen A2 stream type, with instream substrates substantially comprised of boulders and cobbles of all sizes. Some sand and gravel were noted among the benthic particles. Moderate streambank stability was noted.

Bioassessment

Figure 2 summarizes bioassessment scores for aquatic invertebrate communities sampled at the 2 sites in this study. Table 5 itemizes each contributing metric and shows individual metric scores for each site. Tables 3a and 3b show criteria for impairment classifications and use-support categories recommended by Montana DEQ.

When this bioassessment method is applied to these data, scores indicate that biotic health was moderately impaired in the downstream (MO7MCCLC01) reach of McClellan Creek, and unimpaired in the upstream (MO7MCCLC02) reach. Partial support of designated uses was suggested by scores calculated for the lower site, while the upper site fully supported designated uses.

At the downstream site, fewer Ephemeroptera and Plecoptera taxa were present in the sample than expected, and no sensitive taxa were collected. The proportion of filter feeders among functional groups was higher than expected, and the proportion of tolerant taxa in the assemblage was elevated. The assemblage collected at the upstream site appeared to be characteristic of an unimpaired montane stream.

Figure 2. Bioassessment scores for 2 sites on McClellan Creek, August 7-8 2001. Revised bioassessment metrics and criteria (Bollman 1998) used as reference.

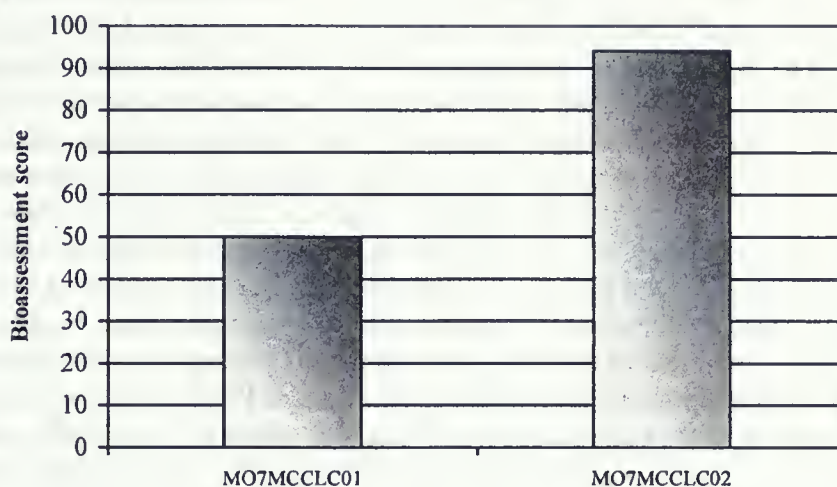


Table 5. Metric values and bioassessments for 2 sites on McClellan Creek. August 7-8 2001. Revised bioassessment metrics and criteria (Bollman 1998) used as reference.

	SITES	
	MO7MCCLC01	MO7MCCLC02
METRICS	METRIC VALUES	
Ephemeroptera richness	5	7
Plecoptera richness	2	4
Trichoptera richness	9	9
Number of sensitive taxa	0	5
Percent filterers	6	9
Percent tolerant taxa	61	5
	METRIC SCORES	
Ephemeroptera richness	2	3
Plecoptera richness	2	3
Trichoptera richness	3	3
Number of sensitive taxa	0	3
Percent filterers	2	2
Percent tolerant taxa	0	3
TOTAL SCORE (max.=18)	9	17
PERCENT OF MAX.	50	94
Impairment classification*	MOD	NON
USE SUPPORT †	PART	FULL

1. Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.

*Use support designations: See Table 3a.



Figure 1. Percentage of students who completed the course on time. *Note:* Control group = students who did not receive the intervention; Experimental group = students who received the intervention.



Figure 2. Percentage of students who completed the course on time over time. *Note:* Control group = students who did not receive the intervention; Experimental group = students who received the intervention.

Aquatic insect communities

The biotic index value (4.84) calculated for the assemblage sampled at the lower site on McClellan Creek (MO7MCCLC01) is moderately elevated compared to expectations for an unimpaired stream in the Western Montana foothills. In addition, the number of mayfly taxa collected at the site was mildly depressed. These findings suggest that water quality at the site limits the benthic community. The presence of the leech *Glossiphonia complanata*, physid and planorbid snails, the mayfly *Tricorythodes minutus*, and the caddisfly *Helicopsyche borealis* all suggest that warm water temperatures may be the major impairment to water quality at this site. Not a single cold-stenotherm was present among the animals collected here.

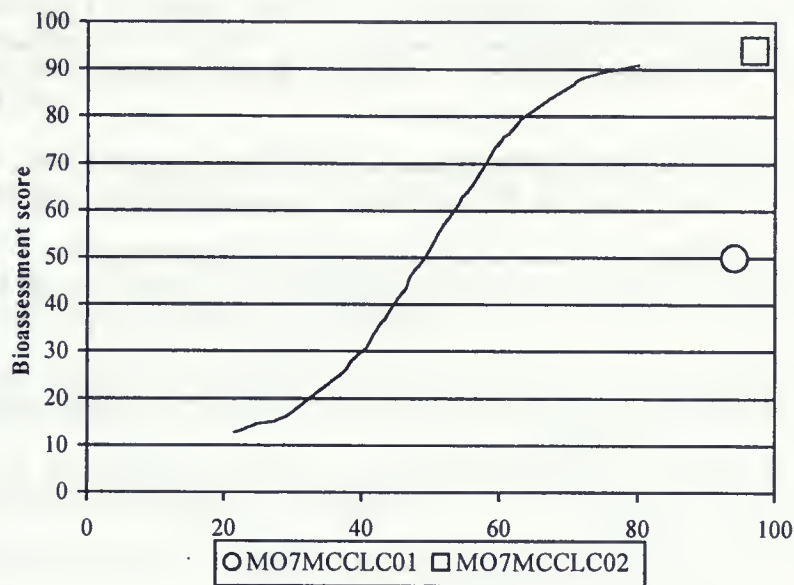
Instream habitat indicators, such as the number of "clinger" taxa and the number of caddisfly taxa, indicate that fine sediment deposition does not substantially limit the availability of hard clean substrates for colonization. Long-lived taxa were relatively abundant in this reach, suggesting that dewatering or other catastrophic events have not recently interrupted life cycles. Functionally, the assemblage is dominated by gatherers and scrapers, suggesting that ample sunlight reaches the stream at the collection site.

At the upstream site (MO7MCCLC02), a low biotic index value (1.52) is coupled with a rich and diverse mayfly assemblage, suggesting clean cold water. No fewer than 6 cold-stenotherms inhabited the site at the time of sampling. Instream habitats were ample enough to accommodate 22 "clinger" taxa, implying that the predominant habitat type was clean hard rock surface, unimpaired by fine sediment deposition. Reach-scale habitat was apparently unaffected by human disturbances, since four stonefly taxa were collected at the site, including the sensitive taxa *Doroneuria* sp. and *Megarcys* sp. Twenty-three percent of organisms taken in the sample from this site were semi-voltine, indicating that no catastrophic interruptions to flow or impairments to water or habitat quality prevented long life cycles here. The functional composition of the sampled assemblage suggests a balanced community occupying a periphyton-rich habitat.

CONCLUSIONS

- The tolerant assemblage collected at the lower site on McClellan Creek suggests warmer water temperatures than expected in a foothill stream.
- Taxonomic and functional composition of the assemblage at the upper site on McClellan Creek suggest undisturbed habitat and clean cold water.
- The relationship between habitat assessment scores and bioassessment scores is illustrated in Figure 3. The red curve in the center of the graph represents the hypothetical relationship between habitat quality and biotic health when habitat degradation is the sole source of impairment to benthic assemblage health (Barbour and Stribling 1991). Water quality impairment is suggested by the low bioassessment score relative to habitat score for the lower site.

Figure 3. The relationship of habitat assessment scores and bioassessment scores for 2 sites on McClellan Creek, August 7-8 2001. The red curve represents the hypothetical relationship between habitat scores and bioassessment scores if habitat quality solely determined biotic health.





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APPENDIX

Taxonomic data and summaries

McClellan Creek

August 7-8, 2001



Report Binder

Stock No./Color

8O571	Black
8O572	Lt. Blue
8O573	Dk. Blue
8O578	Rust
8O579	Exec. Red

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